NETWORKERS

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Deploying Quality of Service Technologies

Session IPS-230

Agenda

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- Introduction
- Architectural Approaches
- QoS Design Guidelines
- Case Studies
- Summary

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Why Invest in QoS?

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To guarantee network resources to meet bandwidth, loss, latency, and jitter requirements of various traffic classes based on application needs.

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Introduction

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- The tools needed to deploy Quality of Service (QoS) end-to-end are available today
- The trick is to understand what behavior is expected by various applications, and what the tools are capable of
- The right tools must simply be applied in the right places to get the desired behavior for the applications

Evolution of QoS Features

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11.x
12.0
12.1
12.2

Network Based Application Recognition (NBAR)
QoS for VPNs
Generic Traffic Shaping (GTS)
Frame Relay Traffic Shaping (FRTS)
Class-Based Shaping
Committed Access Rate (CAR)
Class-Based Policing
Policy-Based Routing (PBR)
Class-Based Marking
QoS Policy Propagation via BGP (QPPB)
Weighted Random Early Detect (WRED)
Priority Queuing (PQ)
Custom Queuing (CQ)
Weighted Fair Queuing (WFQ)
Class-Based Weighted Fair Queuing (CBWFQ)
Low Latency Queuing (LLQ)
Per-VC Low Latency Queuing (LLQ)
Frame Relay Fragmentation (FRF.12)
Multilink PPP Link Fragmentation and Interleaving (MP LFI)
MPLS Guaranteed Bandwidth Services

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Architectural Approaches

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Implementation Options

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- Best-effort model
- Integrated services
- Differentiated services
- MPLS QoS mechanisms
- Policy networking

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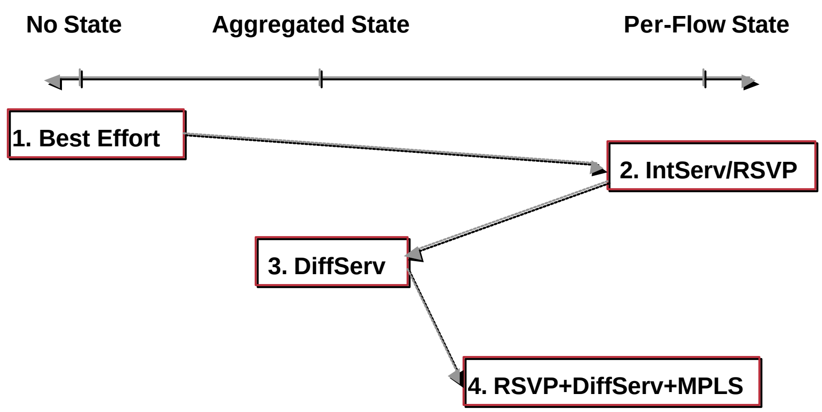
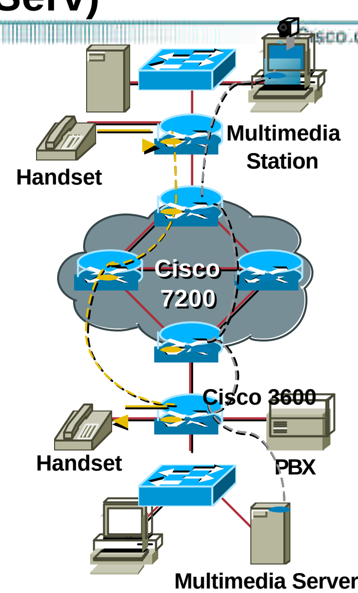
QoS Models



Integrated Services (IntServ)

- **Integrated Services (IntServ) model builds upon Resource Reservation Protocol (RSVP)**
- **Signaled request for network resources along path**
- **Applications:**
  - Voice over IP (VoIP)
  - Video over IP or ATM
  - MPLS Traffic Engineering



RSVP: Signaled Applications

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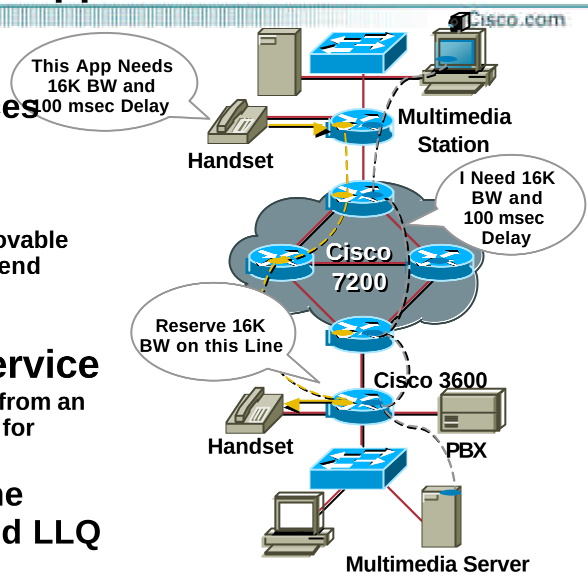
- **RSVP QoS services**
  - **Guaranteed service**
    - Mathematically provable bounds on end-to-end datagram queuing delay/bandwidth
  - **Controlled service**
    - Approximate QoS from an unloaded network for delay/bandwidth
- **RSVP provides the policy to WFQ and LLQ**



RSVP Considerations

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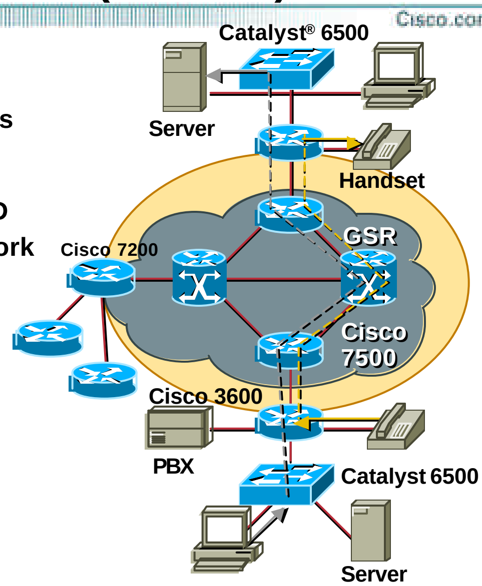
- Requires each node to maintain “soft state” information for each flow
- May not scale to large number of flows, especially on aggregation device
- Currently, only way to give resource-based Call Admission Control (CAC)
- RSVP scalability and performance enhancements being made through RSVP Aggregation and DiffServ interoperability

Differentiated Services (DiffServ)

- IP Precedence marks packets into six classes (2 reserved)
- IP Precedence (weight) for QoS policy e.g., WFQ, WRED
- DiffServ (RFC 2475) framework extends class model, 64 classes (DSCP)
- Applications:
  - Gold/silver/bronze
  - VoIP
  - VPNs
  - Tag/MPLS extensions



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Differentiated Services Code Point (DSCP)

DS field	DSCP	ECN

- RFC2474, definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 headers, Dec ’98
- DS field = ex-TOS field for IPv4 (RFC 791) and traffic class octet for IPv6
- DSCP : Differentiated Service Code Point = 6 bits
  - First 3 bits are CSC: Class Selector Codepoint
- ECN: Explicit Congestion Notification = 2 bits
- TCB: Traffic Conditioning Block
- PHB: Per-Hop Behavior

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The DiffServ Architecture (RFC 2475)

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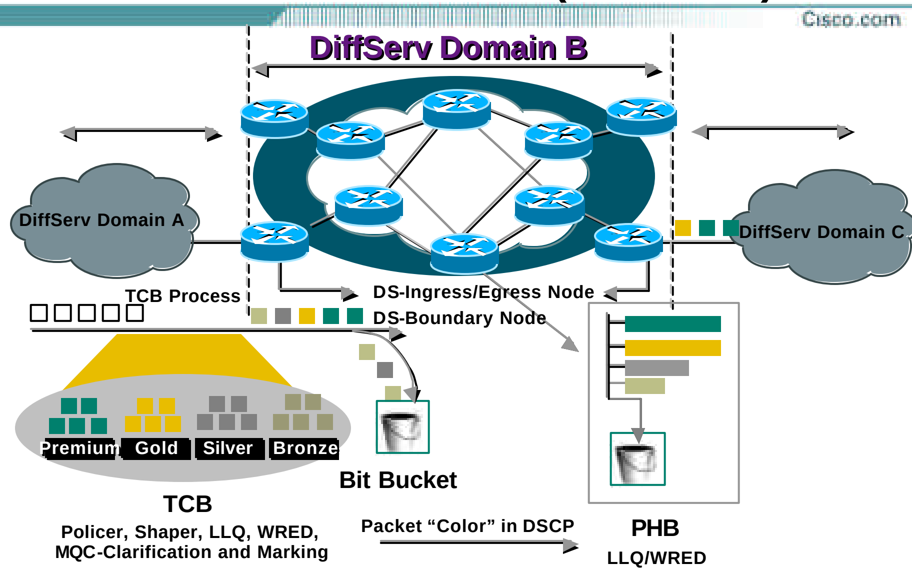

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DiffServ Per-Hop Behavior (PHB)

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- **A Per-Hop Behavior (PHB) is a description of the externally observable forwarding behaviour of a DS node applied to a the set of packets with the same DSCP**
- **PHB may be defined in terms of their resources priority relative to others PHBs or the observable traffic characteristics (delay, loss, …)**
- **PHB defined in terms of behavior characteristics; does NOT mandate particular implementation mechanisms!**

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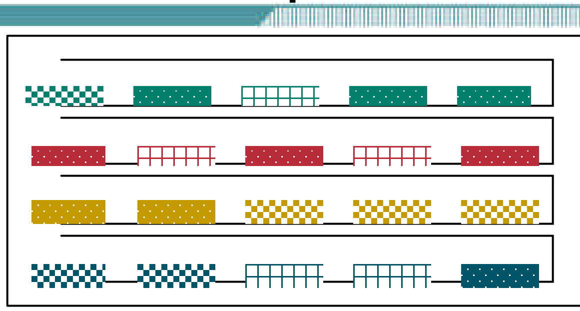
DiffServ PHBs

- **Expedited Forwarding (EF)**
  - EF PHB can be used to build a low loss, low latency, low jitteR, assured bandwidth, end-to-end service
  - Recommended DSCP=101110
- **Assured Forwarding (AF)**
  - Level of forwarding assurance depends on:
    - How much forwarding resources has been allocated to the AF class it belongs to
    - The current load of the AF class
    - In case of congestion within the class, the drop precedence of the packet
- **Default Best Effort (BE)**
  - Recommended DSCP: “000000”

AF PHB Group Definition



AF Class 1: 001dd0

AF Class 2: 010dd0

AF Class 3: 011dd0

AF Class 4: 100dd0

Eg. AF12=Class 1, Drop 2, thus “001100”
CSC=001 Drop Preference=10

dd=Drop Preference

- 4 Independently forwarded AF classes
- Within each AF class, 3 levels of drop pref.
- Within each AF class, RED-like buffer mgt

Cisco MPLS Traffic Engineering

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- Constraint-based routing for path selection
- MPLS tunnel setup via RSVP
- Benefits of IP and L2 ‘consolidation’
- Control of traffic engineering
  - Balance load optimally over existing resources
- Underlying mechanism to achieve IP QoS more efficiently
- DiffServ-aware traffic engineering

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QoS Policy—Based Networking

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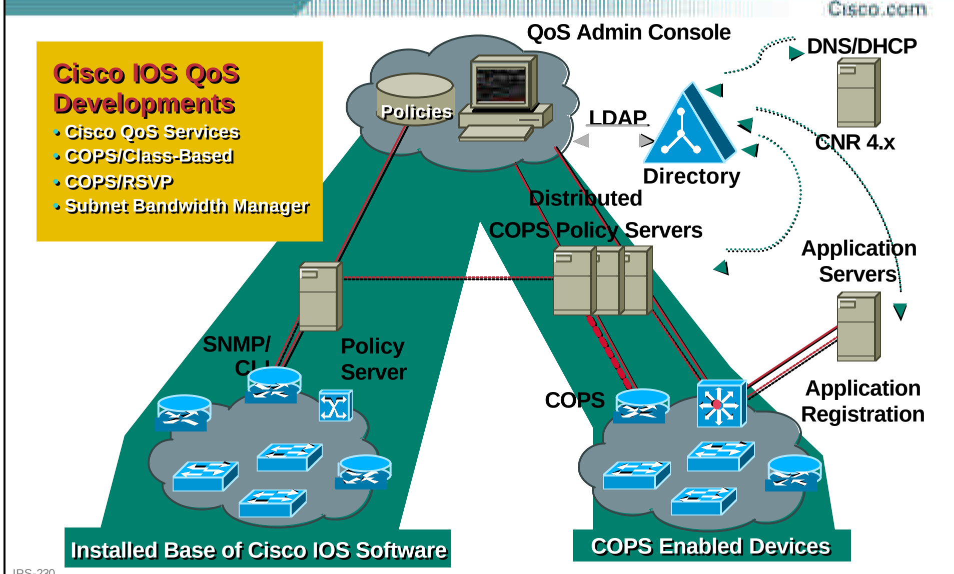

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QoS Design Guidelines

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QoS Design Guidelines

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- Understand application requirements and behavior
- Group applications or users together based on QoS needs—bandwidth, latency, jitter, packet loss
- Use QoS tools at correct places in the network to meet these needs

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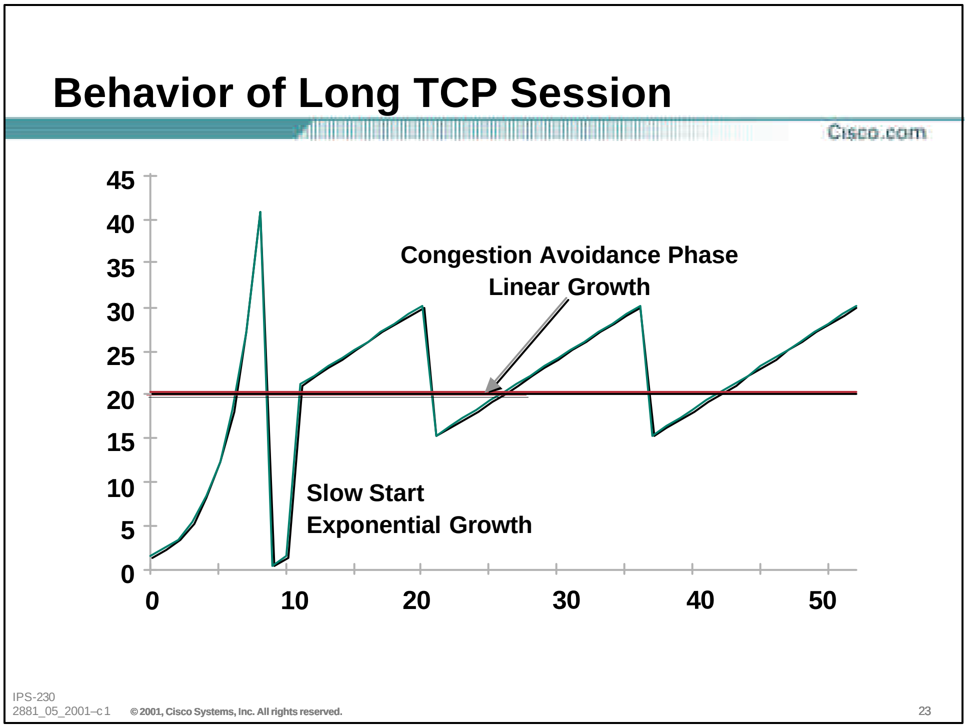
Behavior of Long TCP Session
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45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
Congestion Avoidance Phase
Linear Growth
Slow Start
Exponential Growth
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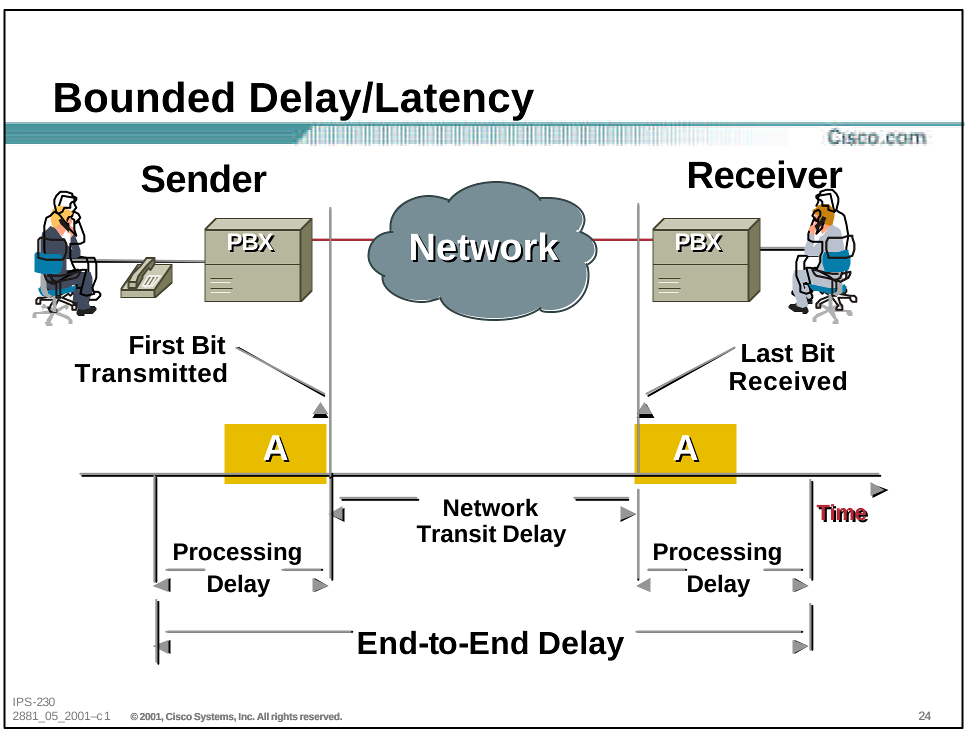
23


Bounded Delay/Latency
Cisco.com
Sender
Receiver
PBX
Network
PBX
First Bit
Transmitted
Last Bit
Received
A
A
Time
Network
Transit Delay
Processing
Delay
Processing
Delay
End-to-End Delay
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Delay Budget

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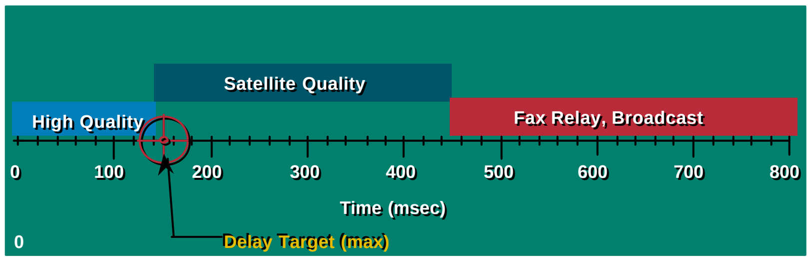
Cumulative Transmission Path Delay



ITU's G.114 Recommendation = 0–150 msec 1-Way Delay

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25

Bounded Delay Variation—"Jitter"

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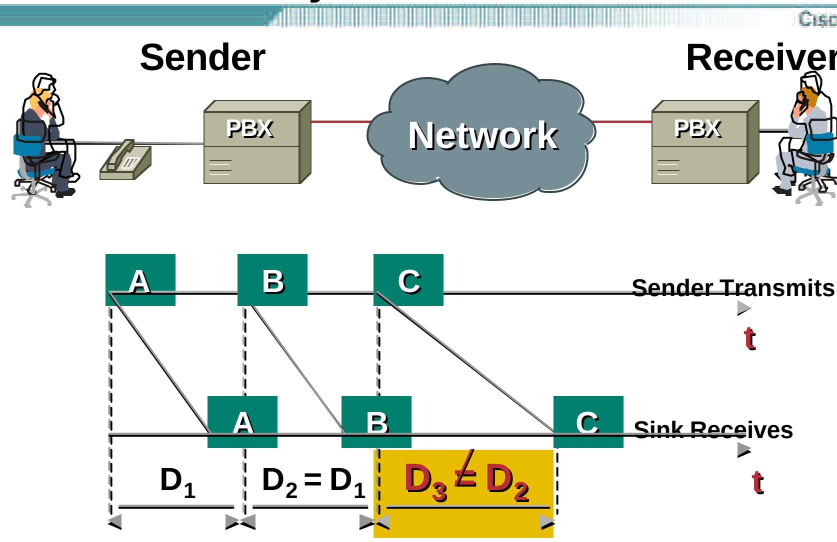

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26

Different QoS Requirements

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	Voice	FTP	ERP and Mission-Critical
Bandwidth	Low to Moderate	Moderate to High	Low
Random Drop Sensitive	Low	High	Moderate to High
Delay Sensitive	High	Low	Low to Moderate
Jitter Sensitive	High	Low	Moderate

Traffic Is Grouped into Classes that Have Similar QoS Requirements

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Sample Class Selection

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Voice, SNA → Gold — Provisioned Service

E-Commerce, ERP-Critical → Silver — Premium IP

E-Mail, Web Browsing → Bronze — Best Effort Delivery

Application Audit ↔ Service Levels

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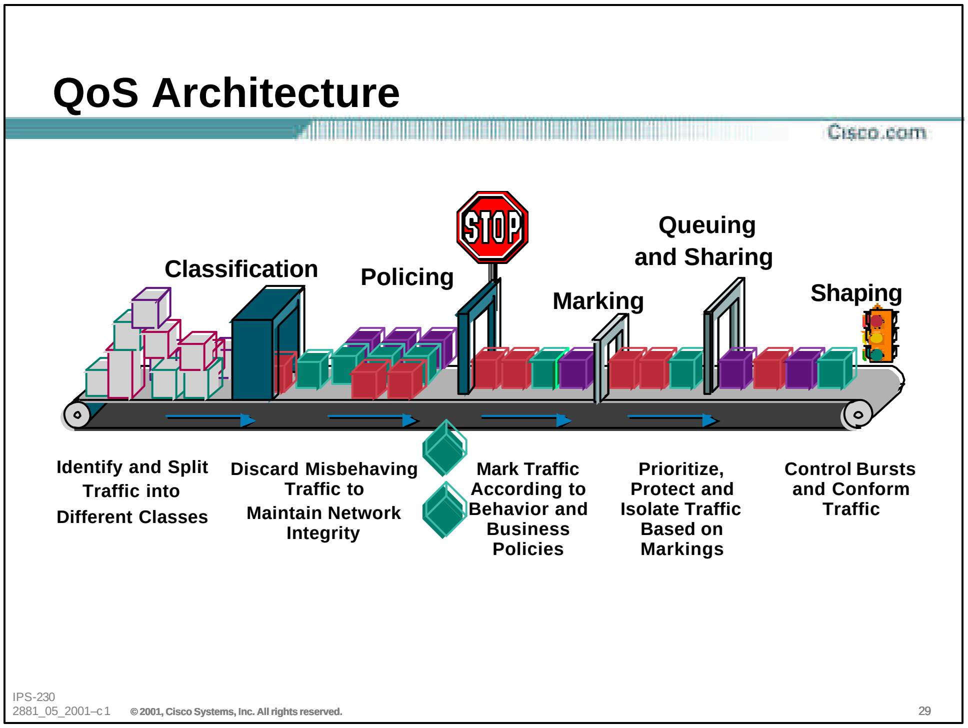
QoS Architecture
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Classification
Policing
STOP
Marking
Queuing and Sharing
Shaping
Identify and Split Traffic into Different Classes
Discard Misbehaving Traffic to Maintain Network Integrity
Mark Traffic According to Behavior and Business Policies
Prioritize, Protect and Isolate Traffic Based on Markings
Control Bursts and Conform Traffic
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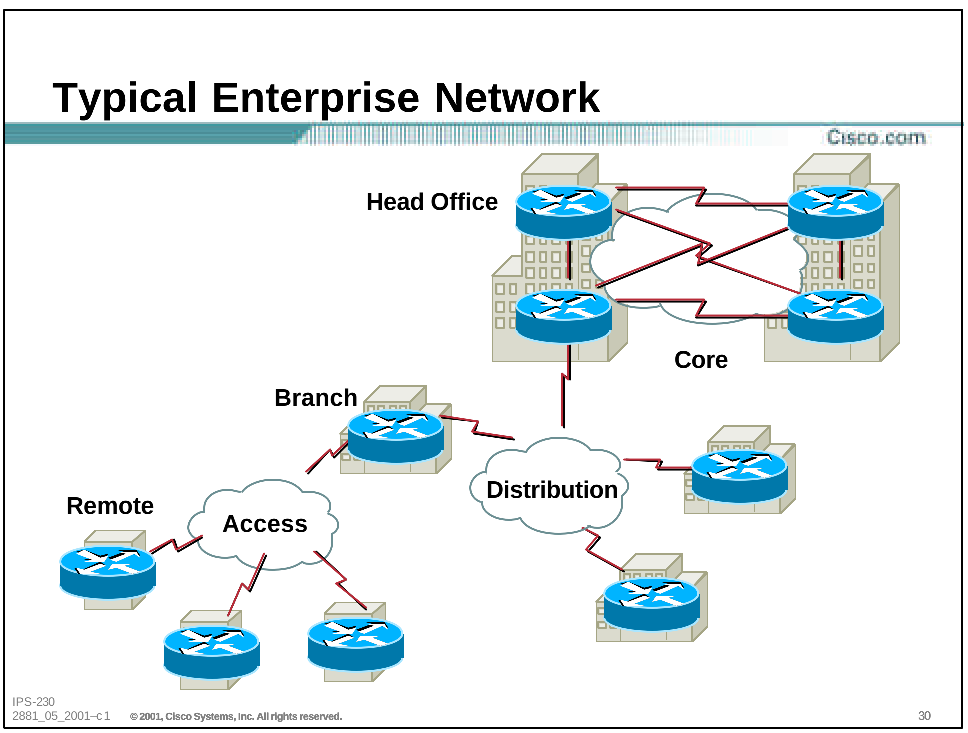
Typical Enterprise Network
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Head Office
Core
Branch
Distribution
Remote
Access
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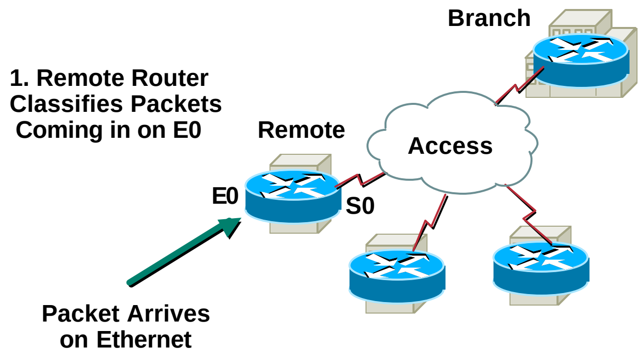
30

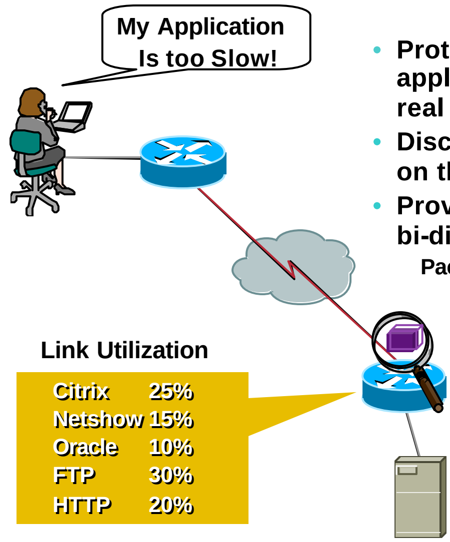
Access Layer: Traffic Conditioning



Traffic Classification

- Classify as far out towards the edge as possible
- Classify locally generated voice packets using “dial-peer”
- If LAN switch can set CoS bits in 802.1p/q header, use these to classify on router
- Any classification technique can be used—ACL, input interface, Network-Based Application Recognition (NBAR), etc.

Network Based Application Recognition (NBAR)



- Protocol discovery analyzes application traffic patterns in real time
- Discovers what traffic is running on the network
- Provides per-interface, per-protocol, bi-directional statistics:
  - Packet and byte counts; bit rates

Mark Citrix Real-Time as GOLD Service and Police FTP

Guarantee Bandwidth for Citrix!

NBAR Capabilities

- A new IP packet classifier capable of classifying:
  - L4-L7 protocols which dynamically assign TCP/UDP ports
  - HTTP traffic by URL or MIME or host type using regular text-strings-expressions (*, ?, [ ])
  - "Sub-port" criteria such as transaction types
- NBAR classification used by QoS features in CEF mode
- More than 24 concurrent URLs, hosts, or MIME type matches
- Matching beyond the first 400 bytes in a URL

Configuration: Classification

```
Router(config)# class-map Gold
Router(config-cmap )# match ip rtp 16384 17383
Router(config-cmap)# exit
Router(config)# class-map Silver
Router(config-cmap)# match protocol Citrix
Router(config-cmap)# exit
```

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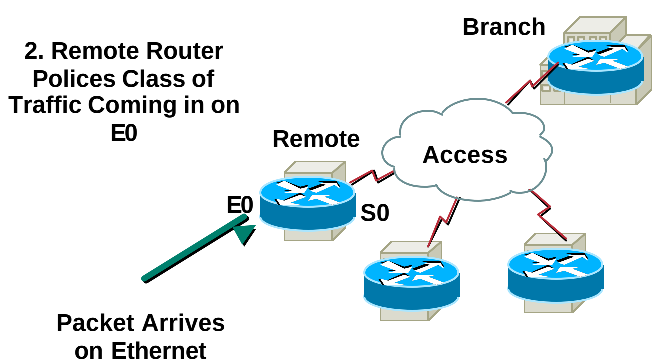
Access Layer: Traffic Conditioning



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Traffic Metering/Policing

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- Optional—allows class of traffic to be restricted to certain rate, so that packets out of contract can be placed into a different DiffServ class or dropped
- Two types:

  RFC 2697: A single rate three color marker

  RFC 2698: A two rate three color marker

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Single Rate, Three Color

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- Usage: mark conforming traffic to low drop priority, mark exceeding traffic with high drop precedence, and drop violating traffic
- Definitions:

  CIR—Committed rate

  CBS—Committed burst size (max)

  EBS—Excess burst size (max)

  Tc—Current size of CBS bucket

  Te—Current size of EBS bucket

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RFC 2697: A Single Rate Two Color Marker

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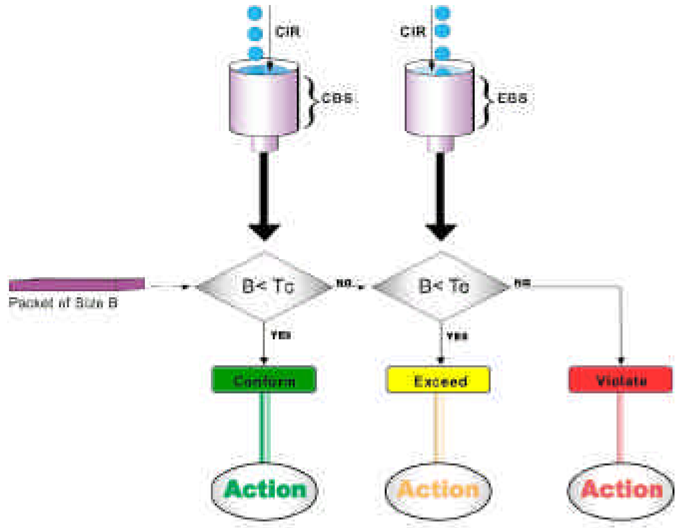

Configuration: Traffic Policing

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Router(config)# policy-map access-in

Router(config-pmap)# class Silver

Router(config-pmap-c)# police bps *burst-normal burst-max* conform-action *action* exceed-action *action* violate-action *action*

Router(config-pmap)# exit

Two Rate, Three Color

- Usage: packets within CIR marked and accounted for differently from packets between CIR and PIR, with anything violating dropped
- Definitions:

  CIR—Committed Rate

  PIR—Peak rate

  CBS—Committed burst size (max)

  PBS—Peak burst size (max)

  Tc—Current size of CBS bucket

  Tp—Current size of PBS bucket

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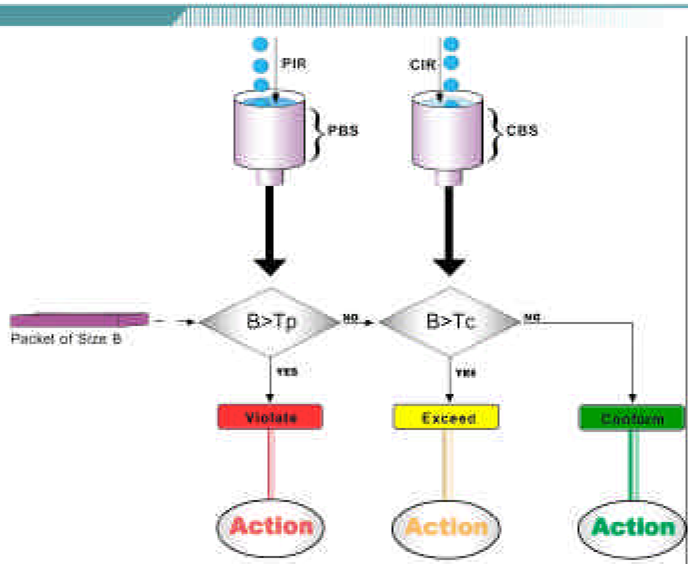
RFC 2698: A Two Rate Three Color Marker



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Configuration: Traffic Policing

Cisco.com

Router(config)# policy-map access-in

Router(config-pmap)# class Silver

Router(config-pmap-c)# police cir *cir* bc *burst-normal* pir *bps* be *burst-max* conform-action *action* exceed-action *action* violate-action *action*

Router(config-pmap)# exit

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Access Layer: Traffic Conditioning

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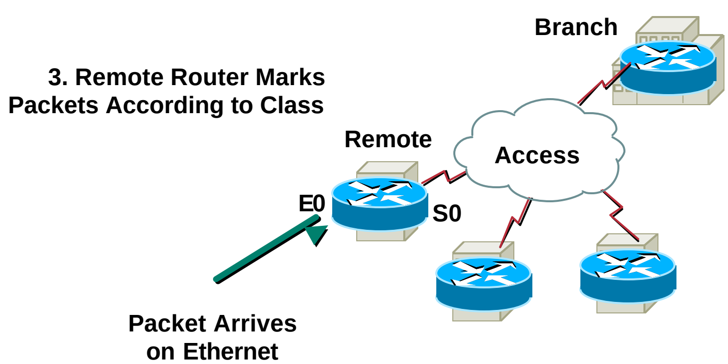

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Presentation_ID.scr

Cisco IOS Class-Based Marking

Type of Marking	# of Bits	Bits Location
IP Precedence	3	Three most significant bits of TOS byte in IPv4 and IPv6 headers
Differentiated Services Code Point (DSCP)	6	Six most significant bits of TOS byte in IPv4 and IPv6 headers
MPLS Experimental (EXP) Bits	3	Part of 20 bit MPLS label
Ethernet CoS Bits	3	ISL or 802.1q/p header
ATM CLP Bit	1	ATM Cell header
Frame Relay DE Bit	1	Frame Relay header

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Configuration: Class-Based Marking

Router(config)# policy-map access-in

Router(config-pmap)# class Silver

Router(config-pmap-c)# set ip dscp 26

Router(config-pmap)# exit

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Access Layer: Traffic Conditioning

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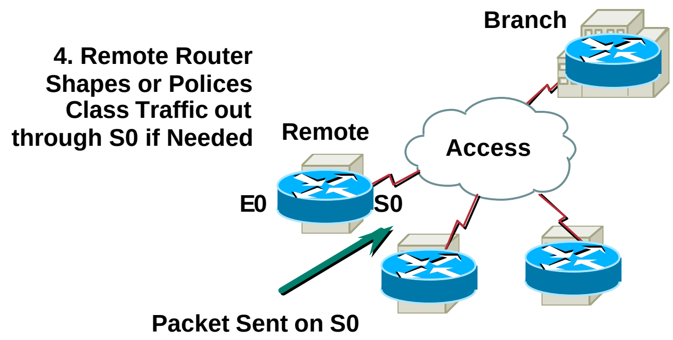

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47

Configuration: Class-Based Shaping

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Router(config)# policy-map access-out

Router(config-pmap)# class Silver

Router(config-pmap-c)# shape {average | peak} cir bc be

Router(config-pmap)# exit

Notes:

bc = committed burst

be = excess burst

"shape peak" shapes to cir*(1+be/bc)

DOES NOT adapt like FRTS today

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48

Frame Relay Traffic Shaping (FRTS) Operation

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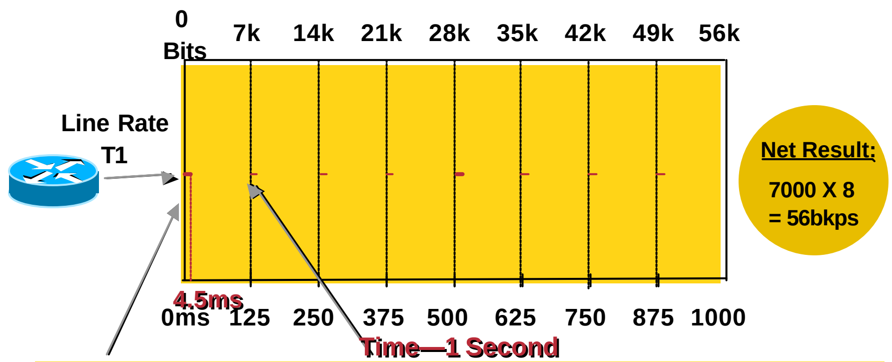
Interval = $\frac{Bc}{CIR}$ → 125ms Interval = $\frac{7000 \text{ Bits}}{56000 \text{ bps}}$



When 7000bits (Bc) Transmitted Credits Are Exhausted no More Packets Are Sent in that Interval—this Can Happen at the 4.5ms Point of the Interval—this could Add 104.5 Milliseconds Delay in between Packets

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Configuration: FRTS

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```
Router(config)# interface serial 0
Router(config-if)# frame-relay traffic-shaping
Router(config-if)# interface s0.1 point-to-point
Router(config-subif)# frame-relay interface-dlci 100
Router(config-fr-dlci)# class frts
Router(config)# map-class frame-relay frts
Router(config-map-class)# frame-relay cir 56000
Router(config-map-class)# frame-relay bc 560
Router(config-map-class)# frame-relay be 0
Router(config-map-class)# frame-relay mincir 56000
Router(config-map-class)# no frame-relay adaptive-shaping
```

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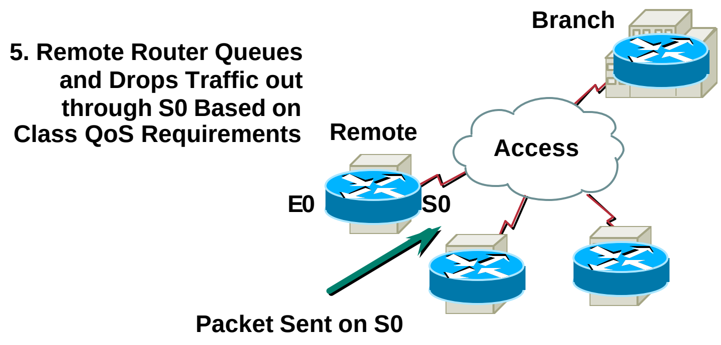
Access Layer: Handling Congestion



 51

Congestion Management

- Determines how to place traffic into queues, and then how to service them
- Low Latency Queuing (LLQ)—adds a priority queue to Class-Based Weighted Fair Queuing (CBWFQ)
- When there is no congestion, behavior is First-In-First-Out (FIFO)

 52

Low Latency Queuing (LLQ) Operation

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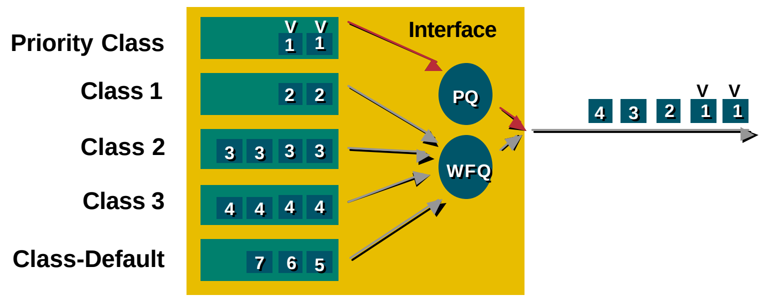

75% Between All the Classes

25% for Locally Generated Control Packets and Layer 2 Overhead

LLQ Configuration

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Router(config)# policy-map wan_policy

Router(config-pmap)# class Gold

Router(config-pmap-c)# priority 128

Router(config-pmap)# exit

Router(config-pmap)# class Silver

Router(config-pmap-c)# bandwidth 256

Router(config-pmap)# exit

Router(config-pmap)class class-default

Router(config-pmap-c)# fair-queue

LLQ Configuration Options

- Priority kbps
- Priority percent %
- Bandwidth kbps
- Bandwidth percent %
- Bandwidth remaining percent %

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Congestion Avoidance

- If a queue fills up, all packets at tail end of queue get dropped—called tail-drop
- Tail-drop causes TCP window to shrink on a large number of sessions, giving the effect of "global synchronization"
- Need a way to make an intelligent drop decision when average queue depth exceeds a minimum threshold

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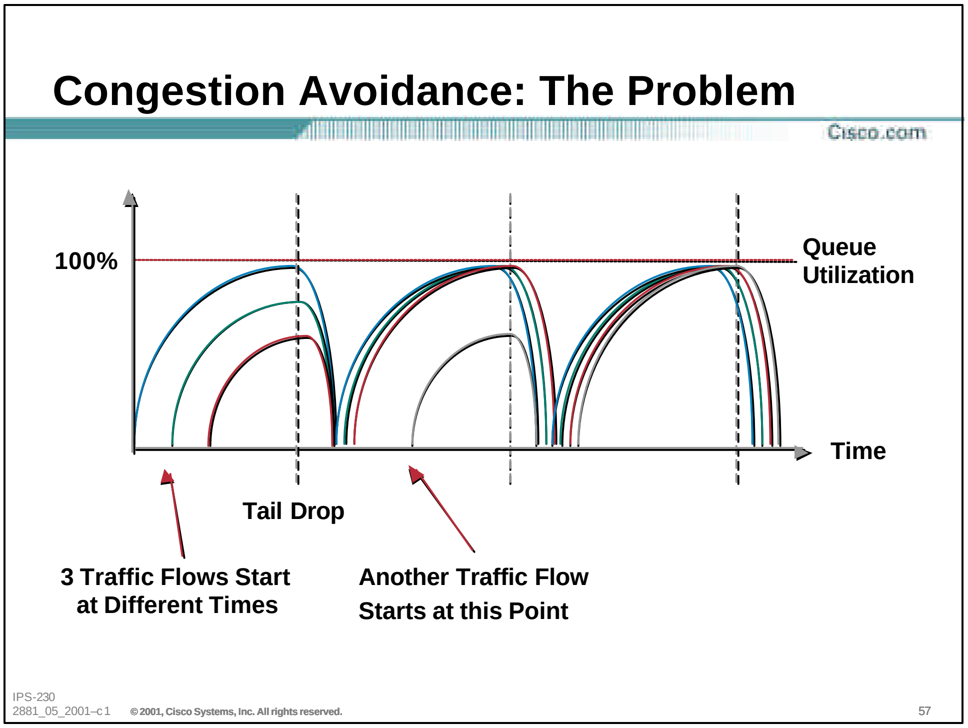
Congestion Avoidance: The Problem
Cisco.com
100%
Queue
Utilization
Time
Tail Drop
3 Traffic Flows Start
at Different Times
Another Traffic Flow
Starts at this Point
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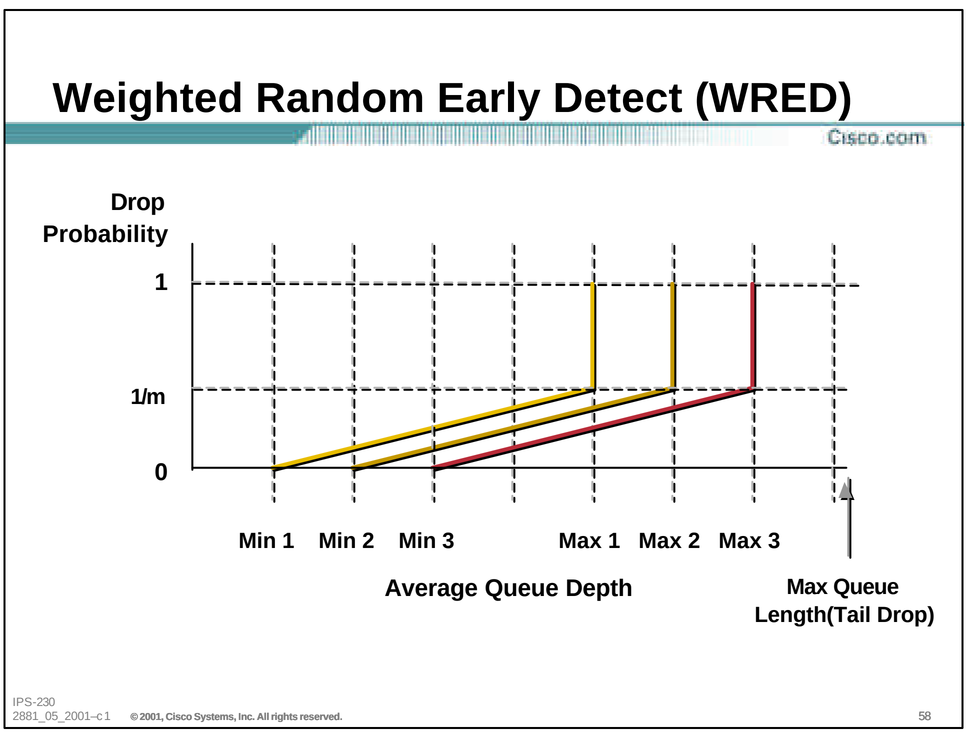
Weighted Random Early Detect (WRED)
Cisco.com
Drop
Probability
1
1/m
0
Min 1
Min 2
Min 3
Max 1
Max 2
Max 3
Average Queue Depth
Max Queue
Length(Tail Drop)
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WRED Configuration

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Router(config)# policy-map wan_policy

Router(config-pmap)# class Silver

Router(config-pmap-c)# bandwidth percent 20

Router(config-pmap-c)# random-detect dscp-based

Router(config-pmap-c)# random-detect dscp *dscpvalue min-threshold max-threshold (mark-probability-denominator)*

Router(config-pmap)# exit

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Distribution Layer

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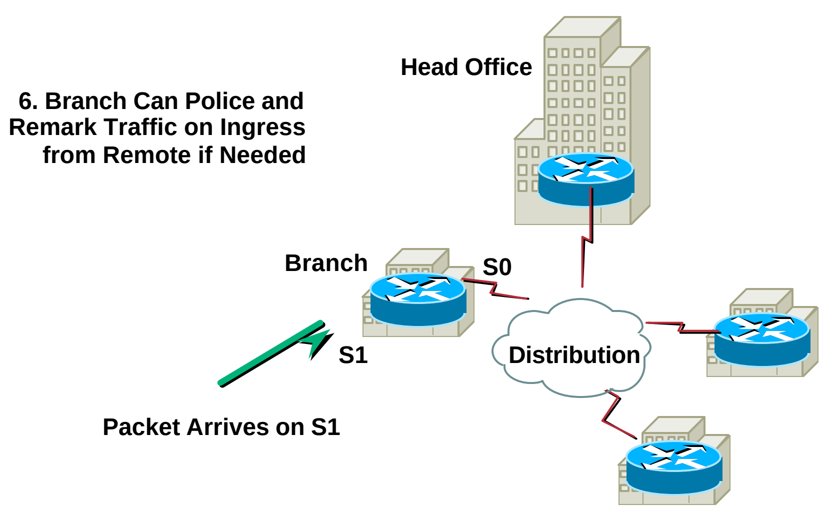

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Distribution Layer

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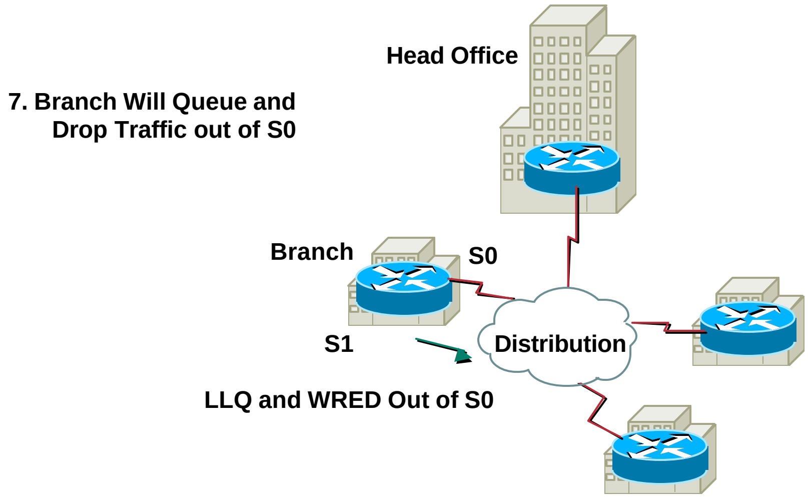

Core Layer

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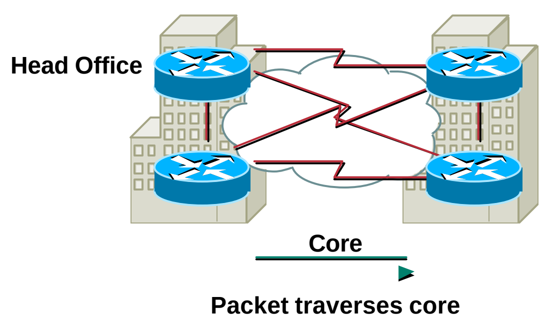
8. Only High-Speed Queuing and Intelligent Dropping in the Core

LLQ, Distributed LLQ (7500), or MDRR (GSR)

WRED to Drop Lower Priority Traffic if Queues Filling up



Cisco IOS® QoS DiffServ Components

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DiffServ Function	Cisco IOS QoS Feature	Behavior
Classification	Modular QoS CLI (MQC)	Recognize Traffic and Place into Classes
Metering	Traffic Policing	Limit Certain Class of Traffic to Configured Rate
Marking	Class-Based Marking	Set Certain Attributes to Place Packet into a Class
Shaping	Class-Based Shaping or FRTS	Smooth Traffic to Configured Rate, Buffer and Queue if Needed
Congestion Management	Low Latency Queuing (LLQ)	Provide EF, AF, and BE Queuing Treatment at each Hop
Congestion Avoidance	Weighted Random Early Detect (WRED)	Drop Lower Priority Traffic First if Average Queue Depth Exceeds Configured Thresholds

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2881_05_2001–c1 63

Modular QoS CLI (MQC)

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- Same across all main Cisco IOS-based platforms
- Separates classification engine from the policy
- Template-based
- Initial release 12.0(5)T
- Uses class-map, policy-map, and service-policy commands

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Configuration: Service-Policy

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Router(config)# **interface serial 0/0**

Router(config-if)# **service-policy output wan_policy**

Router(config-if)# exit

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2881_05_2001–c1 65

Cisco.com

Case Studies

IPS-230
2881_05_2001_c1 66

Case Studies

Cisco.com

- Protect my voice
  - Also admission control
- University scenario
  - Need multicast QoS, limit MP3
- IP VPN service
  - QoS end-to-end through SP network
- Voice, video, ERP, bulk, other
  - Put it all together

Protect My Voice—Links

Cisco.com

- Enterprise network with frame relay and leased line access links ranging from 64 kbps to T1 speeds
- Distribution layer ranges from T1 to DS3 speeds, IP or ATM
- Core has some DS3 and OC-3 POS connections
- 60 remote sites; 15,000 VoIP users

Protect My Voice—Requirements

Cisco.com

- Do everything needed to make sure voice over IP quality is consistently good
- There is also vital internal applications traffic for back office systems
- Everything else can be best-effort for now

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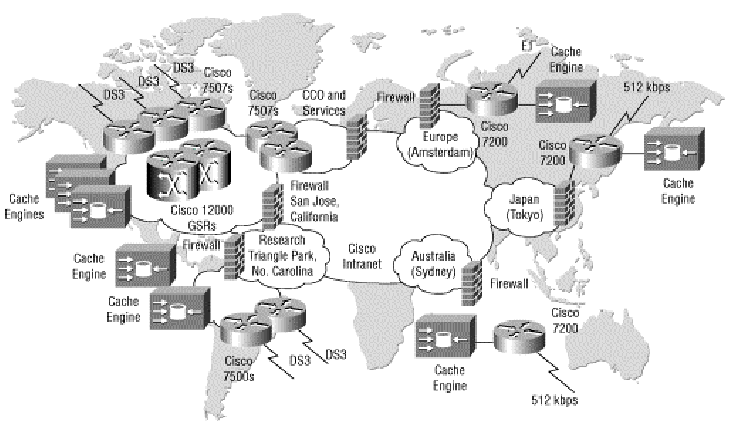
Protect My Voice—Topology
Cisco's Global Internetwork

Cisco.com



Source: Cisco IOS® 12.0 Customer Profile

http://www.cisco.com/warp/public/cc/pd/iosw/profiles/csco_cp.htm

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Protect My Voice—Questions

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- Do you know how to recognize the voice traffic
- How much voice traffic will there be on average—as a maximum
- How much bandwidth do the internal business applications need

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General VoIP QoS Design Guidelines

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- Generally:

  Use Cisco IOS 12.0(7)T or later to get the latest QoS features

  Set IP precedence = 5 on the dial-peer

  Do NOT use WRED on voice queues

  Do NOT mark voice packets as DE or CLP=1

  Goal should be 150–200ms one-way delay

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General VoIP QoS Design Guidelines

Cisco.com

- **Queuing:**

  LLQ—classify voice in a “priority” class

  Set bandwidth of the voice class to the aggregate voice bandwidth on the link or VC (plus allow for a little overhead)

  Alternatively, IP to ATM class of service can be used to carry VoIP on a separate ATM PVC

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2881_05_2001–c1 73

General VoIP QoS Design Guidelines

Cisco.com

- **Link efficiency(for link speeds < 1.2Mbps):**

  Fragment to 10ms delay—optimize size for backbone characteristics—set fragment size so that voice packets do not get fragmented

  For leased lines, set “ppp multilink fragment-delay” on the multilink interface

  For frame relay, set “frame-relay fragment” in the frame-relay map-class—fragment all PVCs carrying data on the interface if at least 1 PVC carries voice

  For ATM(especially in FR-ATM environments), use PPPoATM with Multilink PPP (MP) Link Fragmentation and Interleaving (LFI)

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General VoIP QoS Design Guidelines

Cisco.com

- Traffic shaping (if FR is used as L2 technology):
  - FRTS on the interface
  - Set Bc to 10ms (1/100) of CIR
  - Set mincir >= to voice bandwidth (if adaptive shaping is used)
  - Shape strictly to CIR one PVC carrying voice, don't burst
  - Shape both sides of the VC to prevent egress blocking

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2881_05_2001–c1 75

Protect My Voice—Network Design

Cisco.com

- IP to ATM class of service
- Low latency queuing
- LFI on links below 1.2 Mbps
- FRTS on frame relay links

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Precedence to VC Mapping

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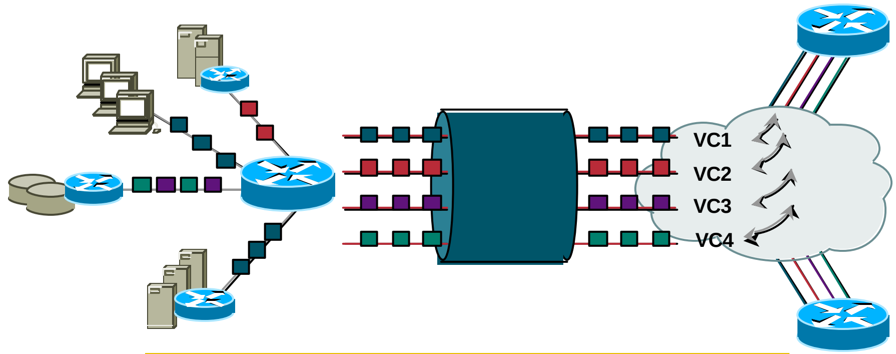

- Multiple VCs for each source/destination
- Separate VC for each IP CoS
- RED (WRED) runs on each VC queue

Multiple VC between Sites

Cisco.com

- **Bundle of VCs**
  - Single routing adjacency
  - VC can be of different ATM classes
  - Map different types of traffic to different VCs
- **VC bumping (priority)**

PVC Bundle Configuration

Cisco.com

```
vc-class atm voice
  precedence 5
  bump explicit 7
  no bump traffic
!
vc-class atm data
  precedence 0–4
  bump traffic
!
vc-class atm control
  precedence 6–7
  bump explicit 4
```

Only Carry Traffic with IP Precedence 5—Only Allow Bumping of Traffic to a VC with IP Precedence 7—Don't Allow other Traffic to Be Bumped onto It

Only Carry Traffic with IP Precedence 0–4—Allow any other Traffic to Be Bumped onto It

Only Carry Traffic with IP Precedence 6–7—Allow Bumping of Traffic onto a VC with IP Precedence 4

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VoIP Call Admission Control (CAC)

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- Protect voice from voice
- What if there is no more priority bandwidth available

  Need to signal H.323 gateway that enough QoS resources not available to guarantee good quality

  Gateway can then re-route call or play appropriate tone

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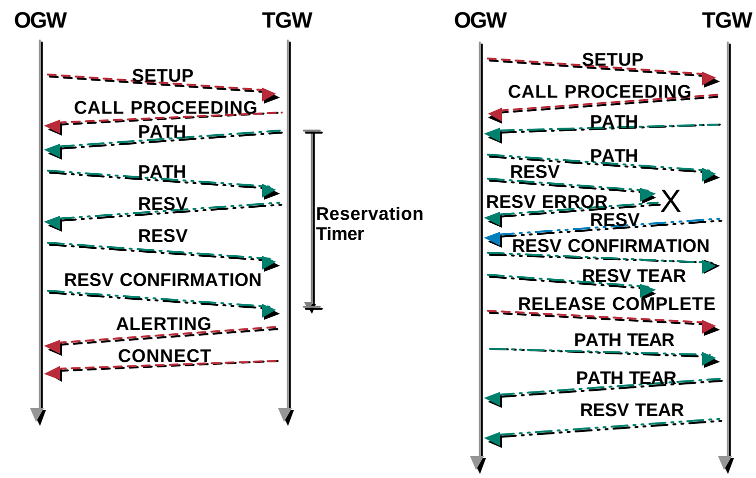
H.323 Synchronization with RSVP

Call Does Not Move to Alerting until Reservations Are Complete

Call Is Disconnected when Reservation Fails



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Configuring H.323 Synchronization with RSVP

```
Router(config)# call rsvp-sync
Router(config)# !
Router(config)# interface Serial0/0
Router(config-if)# bandwidth 1536
Router(config-if)# ip address 10.10.1.1 255.255.255.0
Router(config-if)# fair-queue
Router(config-if)# ip rsvp bandwidth 1152 24
Router(config-if)# !
Router(config)# dial-peer voice 300 voip
Router(config-dial-peer)# destination-pattern 3……
Router(config-dial-peer)# session target ipv4:10.77.39.129
Router(config-dial-peer)# req-qos guaranteed-delay
Router(config-dial-peer)# acc-qos guaranteed-delay
```

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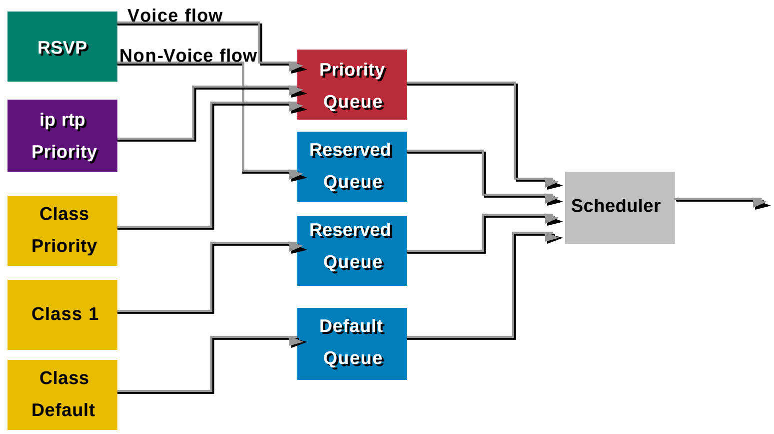
RSVP Support for LLQ



RSVP Support for LLQ

- The RSVP TSpec is compared with PQ profile
- Flows with TSpec within PQ profile use the PQ (no MQC configuration required)
- Flows with TSpec above PQ profile get a reserved queue within WFQ
- A voice-like PQ profile is enabled by default

Configuring RSVP Support for LLQ

Cisco.com

```
Router(config)# interface Serial0/0
Router(config-if)# bandwidth 1536
Router(config-if)# ip address 10.10.1.1 255.255.255.0
Router(config-if)# encapsulation ppp
Router(config-if)# fair-queue
Router(config-if)# ip rsvp bandwidth 1152 256
Router(config)# !
Router(config)# ip rsvp pq-profile voice-like
```

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2881_05_2001-c1 85

Case Studies

Cisco.com

- Protect my voice
  Also admission control
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University Scenario—Requirements

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- **Guarantee 512 kbps to multicast traffic across my campus**

  Application is video-on-demand—requires guaranteed bandwidth, low loss, bounded delay and jitter (but no need for priority service since not interactive)

- **Limit Napster to 10% of my internet link (T1)**

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University Scenario—Topology

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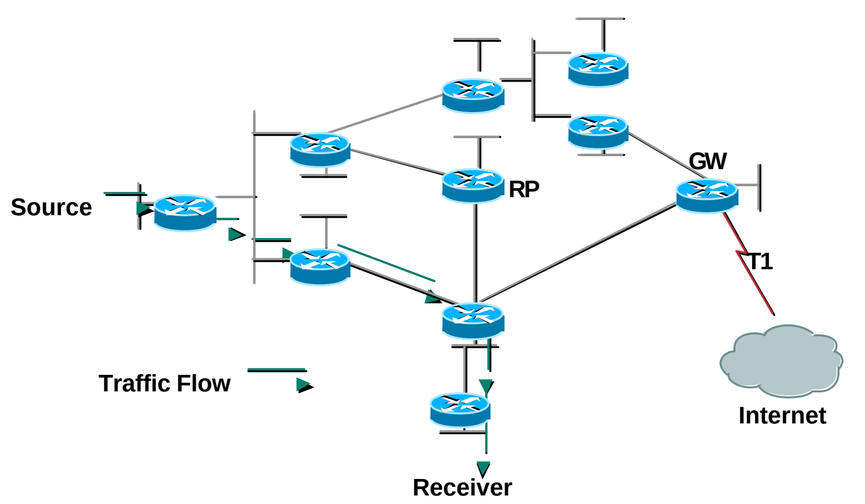

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Presentation_ID.scr

University Scenario—Recommended Design

Cisco.com

- Use policy-based routing or class-based marking to mark IP precedence bits for multicast traffic as close to source as possible
- Use class-based weighted fair queuing (CBWFQ) to guarantee bandwidth
- Can use QoS capabilities on switches as well (discussed in other sessions)
- Use NBAR to recognize Napster and then traffic policing to limit it to 10% of the T1 Internet link

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2881_05_2001–c1 89

University Scenario—Configuration

Cisco.com

On Router Closest to Source:

```
Router(config)# class-map ipmc
Router(config-cmap)# match access-group 100
Router(config)# policy-map markipmc
Router(config-pmap)# class ipmc
Router(config-pmap-c)# set ip precedence 4
Router(config)# interface ethernet0/0
Router(config-if)# service-policy input markipmc
Router(config-if)# !
Router(config)# access-list 100 permit udp any 224.0.0.0 31.255.255.255
```

Note: May also want to reset IP Precedence to 0 for all other traffic

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University Scenario—Configuration

Cisco.com

Queuing Configuration for Most Routers:

Router(config)# class-map multicast

Router(config-cmap)# match ip precedence 4

Router(config)# policy-map univq

Router(config-pmap)# class multicast

Router(config-pmap-c)# bandwidth 512

Router(config-pmap-c)# !

Router(config)# interface ethernet0/0

Router(config-if)# service-policy output univq

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2881_05_2001–c1 91

University Scenario—Configuration

Cisco.com

On Gateway (GW) Router:0

Router(config)# class-map Napster

Router(config-cmap)# match protocol napster

Router(config)# policy-map limitnapster

Router(config-pmap)# class Napster

Router(config-pmap-c)# police 153600

Router(config)# interface serial0

Router(config)# bandwidth 1536

Router(config-if)# service-policy input limitnapster

Router(config-if)# service-policy output limitnapster

IPS-230
2881_05_2001–c1 92

Case Studies

Cisco.com

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IP VPN Service—Requirements

Cisco.com

- Enterprise customer buying IP VPN service (MPLS or otherwise) from service provider requires 3 classes of service:
  - Gold (real-time voice): no loss, low latency, low jitter, guaranteed bandwidth (128 kbps)
  - Silver (ERP application): low loss, guaranteed bandwidth (128 kbps)
  - Bronze (other traffic): best effort
- Link to SP is 512 kbps, simple 2 site example

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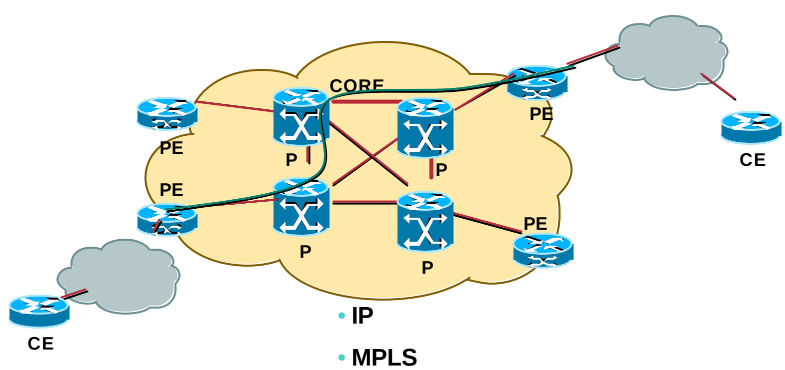
IP VPN Service—Questions to Ask

Cisco.com

- **Can service provider (SP) make SLA guarantees for the 3 classes**
- **What happens to traffic that violates contract**
- **Will IP precedence or DSCP values be changed by SP network**

IP VPN Service—Topology

Cisco.com



- IP
- MPLS

Enterprise Customer Needs IP or MPLS VPN with Guaranteed QoS for 3 Classes of Traffic

IP VPN Service—Recommended Design

Cisco.com

- **It's about control—send traffic to the SP understanding how it will be treated**
  - Make sure Gold class never violates contract
  - Police Silver class to agreed rate, with some bursting capability
  - Allow Bronze traffic to use rest of available bandwidth
- **SP is likely to police the 3 classes and may re-mark or drop exceeding or violating packets**

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IP VPN Service—Configuration

Cisco.com

```
Router(config)# class-map Gold
Router(config-cmap)# match ip rtp 16384 17383
Router(config-cmap)# exit
Router(config)# class-map Silver
Router(config-cmap)# match access-group 101
Router(config-cmap)# exit
```

IPS-230
2881_05_2001–c1 98

IP VPN Service—Configuration

Router(config)# policy-map ipvpn

Router(config-pmap)# class Gold

Router(config-pmap-c)# priority 128

Router(config-pmap)# class Silver

Router(config-pmap-c)# bandwidth 128

Router(config-pmap-c)# police 128000 16000 16000 conform-action set-dscp-transmit 26 exceed-action set-dscp-transmit 30 violate-action drop

Router(config-pmap)# class class-default

Router(config-pmap-c)# set ip dscp 0

Router(config-pmap-c)# fair-queue

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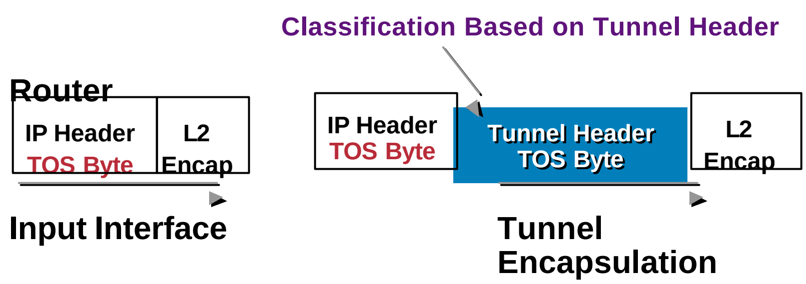
VPN QoS: ToS Field Copy



Copy ToS from original IP header to the tunnel header:

- Done by default for GRE and IPSec

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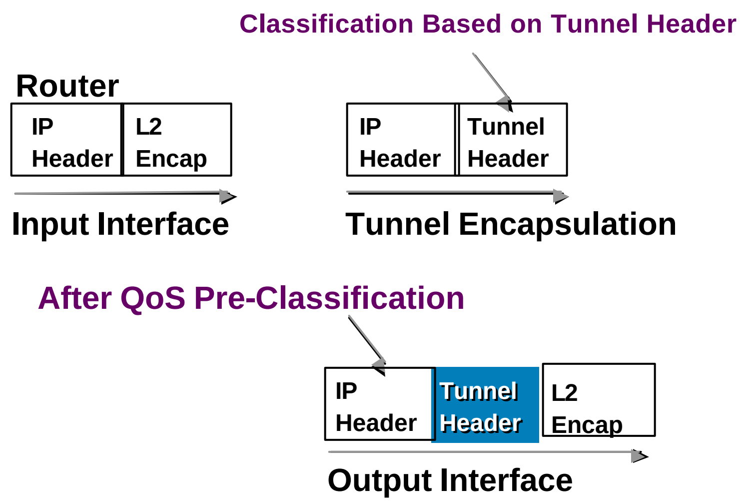
2881_05_2001-c1 100

VPN QoS: Pre-Classification



Configuring QoS for VPNs

- **GRE and IPIP tunnels**

  Router(config)# interface tunnel0
  Router(config-if)# qos pre-classify

- **IPSec tunnels**

  Router(config)# crypto map secured-partner-X
  Router(config-crypto-map)# qos pre-classify

Case Studies

Cisco.com

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 103

The Works—Description

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- Large finance company based in New York but with branches all over the US
- 150 sites connected via Frame Relay to a hub in NY
  - All circuits are T1 with 768 kbps or 384 kbps CIR
  - Central site uses 2 T3 to connect to Frame Relay network
- Currently have 100 sites with VoIP gateways and 5 users per site, assume 12 kbps per call (with cRTP)
- Have separate satellite network for corporate video communications—want to use IPTV

 104

The Works—Requirements

- VoIP (UDP)—must sound crystal clear
- Video (multicast UDP) corporate communications—100 kbps needed, will use 239.200.x.x address space
- Telnet (TCP)—needs guaranteed bandwidth, represents ERP application
- Bulk Transfers (TCP)—need guaranteed bandwidth, must be policed
- Other Traffic—flows get equal share of remaining bandwidth

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2881_05_2001–c1 105

The Works—Configuration Classification

```
Router(config)# class-map voip
Router(config-cmap)# match ip rtp 16384 17383
Router(config)# class-map video
Router(config-cmap)# match access-group 100
Router(config)# class-map erp
Router(config-cmap)# match access-group 101
Router(config)# class-map bulk
Router(config-cmap)# match access-group 102
Router(config)# access-list 100 permit udp any 239.200.0.0
0.0.255.255
Router(config)# access-list 101 permit tcp any any eq 23
Router(config)# access-list 102 permit tcp any any eq 20
Router(config)# access-list 102 permit tcp any any eq 21
```

IPS-230
2881_05_2001–c1 106

The Works— Configuration Policing and Marking

```
Router(config)# policy-map access-in
Router(config-pmap)# class voip
Router(config-pmap-c)# set ip dscp 46
Router(config-pmap)# class video
Router(config-pmap-c)# set ip dscp 34
Router(config-pmap)# class erp
Router(config-pmap-c)# set ip dscp 26
Router(config-pmap)# class bulk
Router(config-pmap-c)# police 128000 conform-action set-dscp-transmit 18 exceed-action set-dscp-transmit 22 violate-action drop
Router(config-pmap)# class class-default
Router(config-pmap-c)# set ip dscp 0
```

IPS-230
2881_05_2001-c1 107

The Works— Configuration DSCP-Based Classification

```
Router(config)# class-map platinum
Router(config-cmap)# match ip dscp 46
Router(config)# class-map gold
Router(config-cmap)# match ip dscp 34
Router(config)# class-map silver
Router(config-cmap)# match ip dscp 26
Router(config)# class-map bronze
Router(config-cmap)# match ip dscp 18 22
```

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The Works— Configuration Queuing and Dropping

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```
Router(config)# policy-map 384out
Router(config-pmap)# class platinum
Router(config-pmap-c)# priority 64
Router(config-pmap)# class gold
Router(config-pmap-c)# bandwidth 128
Router(config-pmap)# class silver
Router(config-pmap-c)# bandwidth 32
Router(config-pmap)# class bronze
Router(config-pmap-c)# bandwidth 64
Router(config-pmap-c)# random-detect dscp-based
Router(config-pmap)# class class-default
Router(config-pmap-c)# fair-queue
```

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2881_05_2001–c1 109

The Works— Configuration Queuing and Dropping

Cisco.com

```
Router(config)# policy-map 768out
Router(config-pmap)# class platinum
Router(config-pmap-c)# priority 64
Router(config-pmap)# class gold
Router(config-pmap-c)# bandwidth 128
Router(config-pmap)# class silver
Router(config-pmap-c)# bandwidth 64
Router(config-pmap)# class bronze
Router(config-pmap-c)# bandwidth 128
Router(config-pmap-c)# random-detect dscp-based
Router(config-pmap)# class class-default
Router(config-pmap-c)# fair-queue
```

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The Works—Configuration FRTS

Cisco.com

```
Router(config)# map-class frame-relay 384k
Router(config-map-class)# frame-relay cir 384000
Router(config-map-class)# frame-relay bc 3840
Router(config-map-class)# frame-relay be 0
Router(config-map-class)# frame-relay mincir 384000
Router(config-map-class)# no frame-relay adaptive-shaping
Router(config-map-class)# frame-relay fragment 480
Router(config-map-class)# service-policy output 384out
Router(config)# map-class frame-relay 768k
Router(config-map-class)# frame-relay cir 768000
Router(config-map-class)# frame-relay bc 7680
Router(config-map-class)# frame-relay be 0
Router(config-map-class)# frame-relay mincir 768000
Router(config-map-class)# no frame-relay adaptive-shaping
Router(config-map-class)# frame-relay fragment 960
Router(config-map-class)# service-policy output 384out
```

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Case Studies—other Considerations

Cisco.com

- Transmit queue limits
- Over-subscription
- Performance
- Multiple routes
- End-to-end
- Cisco IOS version

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Cisco.com

Summary

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Summary

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- The tools needed to deploy QoS end-to-end are available today
- The trick is to understand application requirements and the QoS behavior expected
- Applying the right tools in the right place helps make the DiffServ model scale
- Several QoS management tools are available for provisioning and monitoring

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QoS Management

- You are not alone—several QoS management tools available:

  QDM—QoS deployment manager

  QPM—QoS policy manager

  SLM—Service level manager

  Class-based MIB

Future

- Additional DiffServ platform support
- More policy-based mechanisms
- QoS simplification options
- RSVP aggregation, integration, timers
- Enhanced performance and scalability

Other Networkers QoS Sessions

Cisco.com

- IPS-130: Introduction to QoS
- WMS-210: Deploying multiservice networks
- VVT-213: Deploying QoS for voice and video in IP networks
- IPS-231: Deploying QoS in SP networks
- IPS-330: Troubleshooting QoS technologies
- IPS-430: Advanced concepts and developments in QoS
- PS-560: Power session—QoS essentials

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2881_05_2001–c1 117

Useful Information

Cisco.com

- CCO QoS page

  http://www.cisco.com/go/qos
- Cisco IOS 12.2 QoS documentation
- "IP Quality of Service" book

  http://www.ciscopress.com/book.cfm?series=1&book=173

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2881_05_2001–c1 118

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Deploying Quality of Service Technologies

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Please Complete Your Evaluation Form

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121